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Atomic force microscopy integrated with laser spectroscopy

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Integration of atomic force microscopy (AFM) and laser spectroscopy traditionally makes it possible to obtain more complex information about the object under investigation: whether it is a living cell, a polymer composite, or nanotubes. In the report are given an examples of combined AFM and Raman microscope NTGERA Spectra (NT-MDT Co) application to study both physical properties of the surface (topography, surface potential, magnetic or piezoelectric properties, conductivity, local stiffness) and structural properties measured by Raman spectroscopy. Usually Si cantilevers of top-visual shape are used for optical access to the tip from above by high-res objective (100x, 0.7 NA). It is also possible to use metal needles in the tunneling current microscopy or tuning fork based feed-back. It is possible to carry out combined measurements in a controlled gas or liquid environment, which may be important to maintain the properties of the sample or to eliminate the background low-wavenumbers Raman peaks from the N_2 and O_2 molecules present in the air. The design of the spectrometer makes it possible to use either edge filters or notch filters to suppress laser radiation and provide both Stokes and anti-Stokes scattering, including the THz range down to 10 cm^{-1} from Rayleigh scattering.

Figure 1. NTEGRA Spectra II for combined AFM and Raman.

The most intriguing possibility that appears when integrating atomic force microscopy and Raman spectroscopy is to overcome the diffraction limit due to local amplification of the field near the tip apex [1]. To achieve strong enhancement of the Raman scattering in the Tip Enhanced Raman Scattering (TERS), it is necessary to keep the tip at the surface of the sample as closely as possible. The mode of nonresonant intermittent-contact microscopy, also known as Hybrid mode [2] allows the probe to be held in contact with the surface up to 70% of the time, while eliminating lateral forces during scanning and minimizing the pressing force. In addition, this method is also applicable to keep feedback in the liquid and when the sample is heated, when significant drift of the cantilever tilt is observed.

1. T. Deckert-Gaudig, A. Taguchi, S. Kawata, and V. Deckert, *Chem. Soc. Rev.* **46**, 13, 4077 (2017).
2. Patent US 9,110,092 B1.